

The Research of Metal and Semiprecious Material Surfaces in the Design of Jewelry

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Abstract: The principal theses of the materials visual perception (conjunction of metal-stone) are represented in article in dependence of their functional signification. The regularities that reveal the relationship of the color perception combination of relief texture and its roughness are also considered. The data about color contrast obtaining and relief texture of metal and semiprecious material in the design of jewelry are state. In the process of the research is shown the data of perception texture relieve dependence with quantitative parameter values of estimated surfaces. The influence of material physical properties on the perception of relief texture was detected: the nature of the surface luster, color characteristic of the conjunction of metal-stone, the influence of roughness amount on inserts of stone color parameters, that mute the basic color or make contrast with it and factors that have influence on the specific nature of surfaces light reflection and contrast were marked out. The recommendations for further research of jewelry technique materials surfaces visitation in the process of designing are set out.

Key words: The research, design, designing, visitation, metal and semiprecious materials, jewelry, the perception of materials surfaces, color combination of materials surfaces, structure and texture, relief of texture, contrast

INTRODUCTION

Present-day processes of technical and technological, social and economic and cultural development of society go on in a context of complication and changes in material world conditions of human life activity. Increase of human life processes objectification stipulates the necessity of a comprehended project strategy choice in the development of technical facilities and new things (Yakovlev, 2000).

The necessity of creating objects that correspond with the laws of the technical feasibility and considering on the visual and tactile characteristics and its perception is determined by the standard of living in society. The design takes on this function that helps to adapt technical ideas and industrial solutions to the peculiarity of human perception of the objects in material world. It may be cohere in uniform comprehensive whole in accordance with specific standard of valuables through modification of shapes and color due to demands and conditions of aesthetic perception (Kaukina *et al.*, 2014). In turn the constant increase of the aesthetic level demand to the objects of material world invariably determines the modernization of materials and technologies. Metals and stones without any doubt, take one of the most important places in the history of the human civilization development. Today, the use of metal and semiprecious

materials in different areas of jewelry design is entering to a qualitatively new level. The technology for manufacturing the decorative product or jewelry which combines metals and stones got a higher level in present circumstances of production. This became possible above all to achievements in instrumentation of special and universal machines and also to real current situation prevailing in the present-day jewelry market.

One of the main design aims is the quality improving of art-industrial products. In this sense, art design can be regarded as the main criterion which is the optimal relationship between the standard and beauty (Golubyatnikova, 2011). From the standpoint of design the development of jewelry project assume determination of triune problem. On the one hand the aesthetics of the product must be designed, on the other hand it's necessary to ensure its full functionality and implement a rational choice of materials and technology of its decorating. So, studying of regularities and basic knowledge of the materials processing technology, its aesthetic perception from design point of view is a problem of current interest.

MATERIALS AND METHODS

In spite of the economic crisis, there is a great explosion of interest to non-ferrous metals, their alloys

and stones. This fact determines increasing demand for the assortment expansion in the jewelry industry. Creating and designing of jewelry defines aspiration to harmony in combination with the use of materials and its functions. So, it should be taken into account the fact that metal materials adjoin with minerals in things of jewelry destination. It's rather difficult to find an equal ratio between their functional and aesthetic value. In some products aesthetic component is more important in other the practical side is more appreciated. That's why so important to choose the appropriate form and material as well as methods of manufacture and decorating that are most able to ensure the required quality of the final product. Most specialists, however, use these factors rather thoughtlessly in its superficial forms. As a rule material palette selection is based on compliance criterion of the mineral color to one or the other element of metal, herewith often ignoring the contrast and color combinations. In some cases the situation is aggravated by the fact that some contractors use in one product virtually incompatible with each other elements made of metal and stone with an inappropriate texture and color imbalance.

By this reason an important part of fabricating the project is the nature of its visual and physical interaction with the materials surface that is directly correlated with the process of production and processing. Application of the achievements of materials processing to production requires the designer to be informed about objects of physical environment organoleptic properties and human perception of it (Anonymous, 2000). Uniquely, accomplishment of such problem as objects perception, its color and texture characteristics imply such an important aspect as visual analysis of texture and surface color of jewelry with the use of modern methods of investigation.

Materials may have a wide specter of color and texture characteristics in accordance with scientific data. The color and texture are well-known means of product artistic expression when we appraise the consumer features which is its aesthetic criterion. Aesthetics of the product can be determined by dint of visual contact with the surface of the product due to the interaction of view, tactile and haptic sensations that are related to the perception. Therefore, the analysis of used colors and textures visual perception in the design of any object helps to achieve a high level of its aesthetics.

A number of conditions must be considered during designing of product common nature, shape, size and material that are required for its production. Chosen material should be used rationally, also as its physical and mechanical, technological and decorative properties

(hardness, color, texture and roughness) and to submit general idea of the product to the object shape (Voynich and Naumov, 2015; Naumov, 2012). Based on this criterion it should be noticed, choice of material depends not only on the process parameters but also on the color characteristics. Proficient use of a material color and its combination enhance the product expressiveness.

On the assumption of this, general compositional principles of product formation (volume-spatial structure, shape of product components) should be defined; moreover the optimization of its aesthetic properties that determine the color and tonal combination of materials must be carried out. Lack of information about the opportunities of surface color characteristics and relieve texture obtaining allow determining the relevance of the research. Denoted position defines the aim of this research formation the criteria of material combination selection (conjunction of metal-stone) in accordance with color and texture in the products of jewelry production.

Analysis of the research problem: Turning to the problem of designing the jewelry, the availability of using the decorative properties of natural stone and a combination of non-ferrous metals and alloys in scientific practice should be noted. Particularly such jewelry materials characteristics (metal-stone) as color, luster, transparency and other ones are taken into consideration. Criterion of color, luster and transparency are the main stone features of decorating. The main significance represents by its combination.

The color has three parameters: purity, brightness and saturation. Color purity a-determines the proximity of this wavelength to a reference value, typically to the wavelength of spectrally pure colors (yellow, red, etc.).

Brightness R is an integral color parameter defined by the total amount of light (in the whole range of visible wavelengths) entering the human eye. The relative brightness of the material is the ratio of the intensity of the reflected light to the incident light for the entire visible wavelength range. Relative brightness calculated by the formula similar to the formula for the reflection coefficient taking into account the entire range of wavelengths:

$$R = I_{ref.gen.}/I_{inc.gen}$$

The main luster characteristic is an ability of a material to reflect light in a definite direction. The luster determines by the material surface roughness and existence of (diffuse and specular) reflection. The selection of color combination in the product design occurs relatively reflective properties of materials (Sokolova, 2003).

During the choice of detached operations and processing mode of material surface fully cooperation between consumer, designer and producer on the texture selection stages is impossible without the above information. The external structure of the material or object surface that reflects the shape and relative position of the roughness, usually determines as the texture, including the features of the surface light reflection. Many researchers consider relieve as an important feature of the surface. Textures are divided into two groups (straight and relief) depending on the roughness value and each of this group is divided into smooth and rough (Bayer, 2005; Chernich, 2008). According to the research data was detected that the physical properties of the material has a great influence on the perception of texture relief: the nature of the surface luster, color lightness, presence and severity of texture design, transparency. All emphasized factors influence on the peculiarities of light reflection and surface contrast of materials.

RESULTS AND DISCUSSION

The research of surface roughness and color combinations of conjunction of metal stone relation: In conformity with the fact that metal and semiprecious materials have certain physical parameters which determine the decoration, the necessity of a metal-stone combination consideration from relative contrast side and its use in jewelry arises.

The contrast is the difference of materials brightness. It can be estimated in accordance with the developed on the basis of the contrast coefficient for colors formula (Sokolova, 2003). The contrast between metal and stone can be estimated by the absolute value of the contrast (K) which is defined by the equation:

$$K = R_{\text{met}} - R_{\text{st}}$$

Where:

R_{met} = The brightness of metal material

R_{st} = The brightness of stone

If the value is positive, the contrast is called the direct (the stone is darker than metal) if the contrast is negative, it is inverse and the stone is lighter than metal. The research of visual perception showed that for visual perception a direct contrast is more favorable than other ones (Voynich, 2006). For the evaluation of couple metal-stone, relative contrast may be used which can be calculated due to the equation:

$$K = \{[K]/K\} 100\%$$

The data of relative contrast in the color characteristics depend on the value K that is:

- Barely visible = 30%
- Clearly visible = 30-70%
- Increased = 70-80%
- Sharp = 80%

Wherein, the scale of metal and stone elements values should be taken into consideration relatively the general size of jewelry. Taking into account this information we define three main directions:

- Stone is the dominant element and metal is its decoration (10-20% of the total weight)
- Stone and metal have almost equal scale load (up to 50%)
- Stone is decoration in metal and its mass (30%) of the total weight

Each of directions carries a range of decorative effects and technological features. In the case it is a question of stone and non-ferrous alloys on the basis of copper, because these alloys are inexpensive relatively precious metals as shown in Table 1 where may be noted relative contrast of materials combinations (metal-stone). Using the table, you may successfully select the optimum combination of materials: stone, metal and alloys on the basis of copper, i.e., use the alloys relative contrast combinations correctly: bronze, brass, German silver, nickel silver and gemstones of b and 2 order according to the classification.

The texture of product surface is one of the most important means of artistic expression. In accordance to the relief characteristics the texture is divided into smooth, rough and relief, depending on the visual and tactile (Sokolova, 2003; Chernich, 2008). The visual perception of texture is carried at the expense of black and white contrasts, formed on the surface of materials during its technological processing. As a rule, during the jewelry design and creating process, special attention is attended to the choice of surface texture because the surface status is one of the main components of aesthetic perception and quality of product subject category. The perception of texture surface occurs on two levels: visual (matte or luster) and tactile (smooth and rough). Different roughness or a combination of rough and smooth surfaces creates a versatility of product perception (Table 1).

The complication of project ideas realization using the textured decoration is in the necessity of transferring the subjectively perceived aesthetic texture qualities to the quantitative characteristics that are required for the products manufacture. Concerning to this, the actual design problem is the establishment of authentic

Table 1: Relative contrast of materials combinations (metal-stone)

Alloys	Relative contrast (%)			
	10-30	30-70	70-80	More than 80
Nickel silver	Rhinestone	Nephritis	Lazurite	Haematite-bloodstone
CNZ	(smoky, colorless)	$C_2(MgFe)_3^*$	$Na_3Ca[AlSiO_4]_5S$	Fe_2O_3
Cu-14,6%	SiO_2	$[Si_4O_{11}]_2(OH)_2$	Charoit	Obsidian
Ni-20,4%, Zn	Turquoise	Malachite	K_2NaCa_5	SiO_2
Bronze	$CuAl_6[PO_4]_4(OH)_8 \cdot 4H_2O$	$Cu_2[NO_3](OH)_2$	$[Si_4O_{10}]F \cdot 3H_2O$	Hawkeye
Brass		Agate	Jasper	SiO_2
		SiO_2	SiO_2 80-95 %	
		Amazonite	Al_2O_3 and Fe_2O_3 to 15 %	
		$R[AlSi_3O_8]$		
		Rhodonite		
		Mn, Ca		
		$[Si_5O_{13}]$		

relationships between human perception and quantitative characteristics of texture. The solution of this problem in our research was in identifying the possibility of materials relief texture perception (conjunction of metal-stone) with certain numerical values of the relief parameter. To solve it, the methodic that is based on the relationship of expert quality relief indicator, estimates. It's should be taken into account the possibility of its definition over the entire range of the materials height roughness surface while the quantifying relief indicator selection (Chernich, 2008). We offer another approaches in surfaces decoration in the development of design of the art-industrial souvenir products group (jewelry boxes, candlesticks, etc.).

We developed samples of metals and alloys surface decorating with wire of different diameters (0.7-1.2). The degree of developed samples decorativeness depends on: of the wire diameter, density of soldered elements, the height of the resulting relief. These types of textures we define as relief with an ordered pattern as shown on Fig. 1.

Presented samples are not recommended for the decoration of jewelry, because it is not ergonomic and requires additional surface areas of the product which is provided in the manufacture of bulk products. Presented graph of the wire diameter, the density and height of soldered elements of relief (1-5 mm) dependence allows you to create invoices, recommended for decorating the surfaces of bulk art and industrial products (Fig. 2). To use textured surfaces of metals and alloys in the design of art and industrial products in wright way, we recommend: fr jewelry to use a combination of luster and relief surfaces at relief roughness (>0.1). For souvenir product group to use the roughness relief (1-5 mm) and the density of the roughness not $<50\%$ and not more than 70%. For this type of texture irregularities pattern we should use invoicing ordered for one and for the other group of products. Relief height, mm.

Thus, provided experimental research extends the features of art technologies of processing the

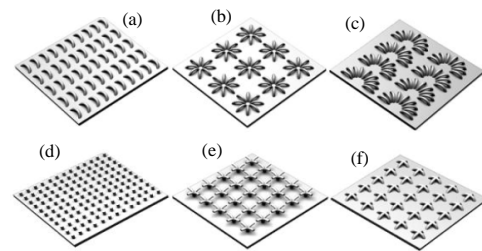


Fig. 1: Kinds of different texture samples

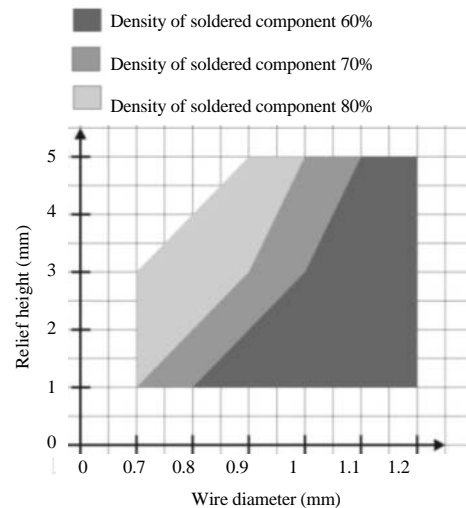


Fig. 2: Graph of the wire diameter, the density and height of the relief soldered elements

semiprecious stones, metals and alloys. We have developed techniques of surface decoration which will offer the promise of new designs that should be used in creating art and industrial products. According to this methodic, decorative metal elements (+stone) can be classified by their surface roughness:

- Mirror (smooth)
- Matte (rough)
- Relief

Surface roughness is a characteristic of microroughnesses size range defined by one of the following parameters: arithmetic mean of Ra profile deflection, roughness height R_z :

$$R_z = [(h_1+h_3+\dots+h_9)-(h_2+h_4,\dots,+h_{10})]/2$$

where, h = number of measurement. The arithmetic mean of profile deflection is the average value of distances (Y_1+Y_2, \dots, Y_n) from the point of the measured profile to its middle line which is calculated as follows:

$$R_z = (Y_1+Y_2+Y_3+\dots+Y_n)/n$$

where, n = number of measurements. The surface relief is considered as the complex of the surface forms, differing in shape and size. Relief surface is usually characterized by the profile parameters. Depending on the length of the profile on which roughness occur, it is divided into wavy (>8 mm), rough (8, ..., 0, 1 mm) and submicro rough (<1 mm).

One of the possible application areas of these results and recommendations is a decorating of products with diversified surfaces. Quite often, combining areas with different textures on a material surface, it is important to achieve the contrast between them. In that case, if the contrast must be obtained through the areas with different relief surface, step of roughness should be defined in each of site, providing different variants of perception.

Thus, provided experimental research extends the visualization of the selected materials and features of art technologies of processing the semiprecious stones, metals and alloys. The received data provide the prospects of new design solutions and it can be used in the implementation of creative ideas in terms of jewelry production.

CONCLUSION

The results of research show defined ratio relief textures (metal, stone) verified by the respondents interview about the visual qualitative assessment of materials samples relief in combination of metal and stone and developed contrast coefficients. While using textured surfaces of metals and alloys in the design of products, we recommend: to use a combination of luster and relief surfaces for jewelry if the surface roughness of the relief (0, 1), to use the relief roughness (1-5 mm) for the

products of the art and decorative groups. Using the relative contrast of combinations (non-ferrous alloys-stone), it is possible to choose the optimum mineral for jewelry made of German silver and use this method in jewelry design extensively. The correct choice of the stone inserts roughness degree in jewelry enhances its aesthetic value and influence on the performance. It was found that the degree of roughness affects the color parameters of the stone inserts which may mute its base color or contrast with it. Stones with monochrome color can acquire aesthetic characteristics by creating a high degree of roughness on its surface in combination with a smooth surface of the metal which provides on the surfaces trick of the light, thereby creating a contrast. The received data provide unlimited opportunities in the creation of new original products and compel attention to the combinations of colors and textured surfaces (metal-stone) that are not taken into account in jewelry design.

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